AVL Testbed Control and Simulation on Engine and Powertrain Testbeds

APPROACH

Decades of experience in the field of testbed control as well as detailed knowledge of the development processes of our customers have significantly influenced the development of AVL testbed controllers. The need for precise real-time simulation models is increasing with the "road to rig" approach. The major challenge in today's vehicle development is to rapidly shorten vehicle development cycles. Vehicle simulation which is more than just vehicle inertia simulation enables significant progress in vehicle optimization and calibration, e.g. driveability as well as real world emission and fuel consumption optimization. AVL provides a stable and robust virtual vehicle model for engine testbeds which enables the simulation of real-world shaft oscillation phenomena (e.g. jerk). The counterpart for powertrain testbeds is a patented solution for the vehicle dynamics with wheel slip simulation. These requirements led to the creation of a modular and scalable controller with integrated simulation environment which ideally covers all requirements from individual testbeds up to applications in large-scale test facilities.

BENEFITS AT A GLANCE

- Approved safety concept for unmanned operation, 24/7
- Central administration of parameterization in test facilities
- Fast road to rig due to highly accurate real-time simulation
- Open simulation environment for the modular integration of customer real-time models
- Central administration and distribution of real-time applications in a test field

TASK

Parameterizing engines and their variants for different vehicles and countries constitutes the highest expenditure of time in the development cycle today. To accomplish this on testbeds in an automated manner, it is essential to have precise control over test subjects and the load facility.

Increased efficiency

To increase efficiency, it is necessary for control parameters to be managed centrally in the test facilities, and it must be possible to unambiguously associate these parameters with the test results.

Operational simplicity

During the operation of the testbed control system, the operator requires only minimal expert knowledge. Uniform, graphically supported, online-compatible parameterization that is also continuous across different testbed types reduces training costs as well as errors.

Consistent usability

The option of adding functionality when specifically required allows for targeted investments. Here, the modular structure of the control system offers ideal adaptability to the current requirements with regard to measurement value collection, control functions and real-time platform.

REFERENCES

All manner of applications have been successfully equipped with AVL EMCON™: from simple testbeds for continuous operation, development testbeds with vehicle simulation, powertrain testbeds and component testbeds, all the way to racing testbeds. Globally, several large-scale test facilities with more than 30 testbeds profit from complete integration into the testbed automation system. AVL ISAC™ offers a scalable and robust simulation solution from road load, vehicle inertia and powertrain oscillations to wheel slip. The flexibility and open character of the system allow the customer-specific adaptations and the direct integration of MATLAB®/Simulink® control algorithms which can be created by the user. This makes the AVL ARTE.Lab™ real-time simulation environment the ideal extension for specific simulation needs at the testbed.

Driveability Evaluation and Simulation

Over 10 years of experience in driveability evaluation and simulation. More than 50 % of all OEM's and transmission manufacturers successfully use AVL-DRIVE™ and AVL VSM™ in engine and powertrain development and for quality assurance.

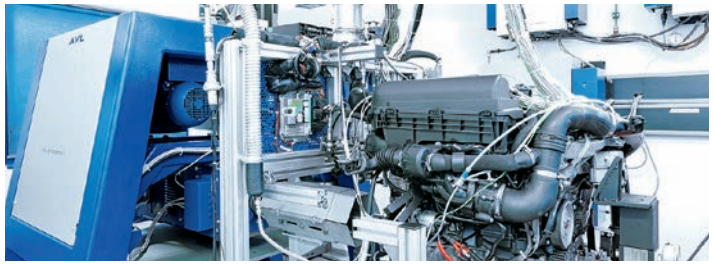
Installed Base

More than 3,400 testbed control systems of the current generation, including stand-alone ones, are in successful use, proving their capabilities around the clock.

A CONTINUOUS CONCEPT FOR ALL TEST JOBS – EASY TO OPERATE, SCALABLE, APPROVED ON MORE THAN 3,400 TESTBEDS.

Dynamometer Control Stand-Alone BME 400

The operating panel P400 is integrated in the Stand-Alone controller case. The F-FEM-CON Advanced provides the controller with I/O for control and monitoring of the dynamometer. The F-FEM-DIO provides 16 additional digital inputs and outputs.



The AVL Stand-Alone digital dynamometer control systems consist of hardware and software for controlling a variety of dynamometers. The system uses proven algorithms to control the dynamometer and, depending on the configuration, also combustion engines. The dynamometer conditions are monitored with predefined and definable responses. The control system has an ergonomically designed operating panel. Incremental pulse wheels permit the exact setting of demand values while the bumpless change of control modes is ensured. The LCD shows demand and actual values as well as parameter settings and operating menus. Alarm and warning messages are also displayed. Function buttons with LED status are available for selecting operating modes and control functions.

TECHNICAL FEATURES

The control software operates on powerful INTEL™ hardware with an INtime® real-time operating system. The input and output of signals to the dyno and to the throttle actuator happens via the F-FEM-CON Advanced and F-FEM-DIO modules which are connected via an IEEE1394 interface. The operating panel allows the operation of the dyno using push-buttons and incremental pulse wheels. Different control modes are used to control the torque or speed of the dynamometer and the throttle position of the unit under test.

APPLICATION

AVL Stand-Alone dynamometer control systems have multiple interfaces to connect to all types of testbed automation systems. To use the parameterization capabilities of AVL PUMA Open™, the Stand-Alone control system can be upgraded to be operated via the AVL automation system.

BENEFITS AT A GLANCE

- Precise operation through excellent torque and speed control stability over the whole performance range
- User-friendly handling through the ergonomic design of operating elements and flexible parameter adjustment via the display
- Stand-alone operation
- Bumpless change of control modes
- Upgrade of control system to be integrated in the AVL testbed automation system AVL PUMA Open™
- Communication with a host system by means of hybrid or digital interfaces like CAN, Ethernet, RS232
- Reliable and approved safety concept

Engine & Dyno Controller EMCON Stand-Alone Advanced

The AVL EMCON 400 Stand-Alone Advanced is a complete digital testbed control and monitoring system for a combustion engine and dynamometer on an engine testbed. Like the BME 400, it has an ergonomically designed operating panel and the same control I/O. AVL EMCON 400 Stand-Alone Advanced includes a runtime environment to execute MATLAB®/Simulink®-based real-time applications created with AVL ARTE.Lab™ on the same controller HW. Real-time applications can be started individually or automatically with AVL EMCON 400 Stand-Alone. An AVL EMCON Stand-Alone Advanced web client enables the parameterization of the controller by using the standard browser on the office PC or directly on the controller workstation. The Web Client provides a number of intuitive and user-friendly GUIs to edit some of the most frequently used AVL EMCON database arrays.

TECHNICAL FEATURES

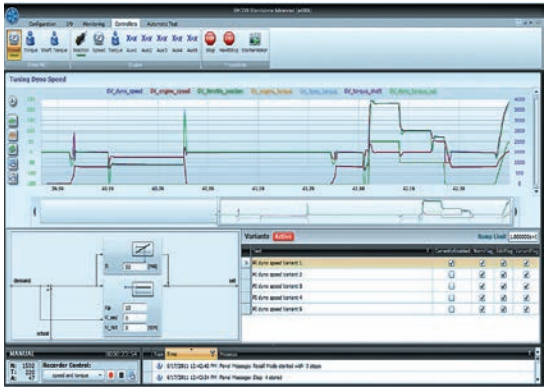
The control software operates on a powerful INTEL™ hardware with an INtime® real-time operating system. It uses the same control I/O as the BME 400 and the AVL automation system AVL PUMA Open™. As the same hardware is used, a direct upgrade path to AVL PUMA Open™ is available.

APPLICATION

Like the BME 400, the AVL EMCON Stand-Alone Advanced can be connected to all types of testbed automation systems by means of different hybrid or digital interfaces. At the same time, parameterization of the controller is possible by using the standard web browser on the office PC connected via Ethernet. The MATLAB®/Simulink®-based real-time applications can automatically be integrated while model start/stop and online parameterization is managed via a common application desktop.

BENEFITS AT A GLANCE

- Features as of Stand-Alone BME 400
- Additionally full support of combustion engine control
- Fast controller parameterization due to user-friendly GUI
- Online graph for support of controller tuning
- Execution of customer-specific MATLAB®/Simulink®-based real-time models on the same AVL EMCON Stand-Alone Advanced HW
- Automatic real-time model integration on the AVL EMCON Stand-Alone Advanced HW
- Upgrade of control system to be integrated in AVL PUMA Open™



Access to the parameters of the controller I/O, dyno and engine via the standard web browser. An online graph supports controller tuning.

EXPERIENCE THE PERFORMANCE

AVL EMCON 6™

MARKET REQUIREMENTS

Better comparison of vehicle components

In series production the quality of produced parts needs to remain on the highest level to fulfill the end customer's expectations. Decreasing quality produces serious damage to a company's reputation and leads to expensive product recalls.

Safety for expensive prototypes

Prototypes of newly-developed vehicle parts are rare and expensive. When testing the prototypes' limits – for example, their performance or longterm durability – a reliable safety net is important.

AVL SOLUTION

AVL EMCON 6™ is the leading control and monitoring system for engine, e-motor, powertrain and chassis dyno testbeds. Based on proven control algorithms, it provides an accurate reproduction of test cycles.

ETC FEM FIO in operation

AVL EMCON 6™ is fully integrated into the AVL PUMA Open 2™ automation system. AVL EMCON 6™ fully supports the AVL Integrated Open Development Platform.

BENEFITS AT A GLANCE

- Bundling of know-how gained from engineering and testing
- EtherCAT® dyno interface for fast control of up to 10 kHz
- Very low latency time in control loops
- Reliable and approved safety concept
- Worldwide racing experience
- Future-proof due to application-specific solutions

ENRICH YOUR TESTING

AVL ARTE.Lab 4™

AVL ARTE.Lab 4™ is an open simulation environment for the integration of real-time applications into AVL PUMA Open 2™ and AVL EMCON Stand-Alone Advanced. AVL ARTE.Lab 4™ uses MATLAB®/Simulink® for modeling of engine and powertrain components and systems as well as other real-time applications. It consists of the development environment AVL ARTE.Lab 4™ Studio SDK and the run-time environment for the execution of real-time models AVL ARTE.Lab 4™ RTE. A generic Model Parameter Editor (MPE) allowing the smooth management of the model parameters at run-time is provided.

AVL ARTE.Lab 4™ Explorer is an extension to visualize internal processes of the MATLAB®/Simulink® based real-time applications. The model development is done on a development PC where the model behavior can be analyzed and the real-time capabilities of the application can be tested before the model deployment on the testbed which saves testbed time. The model integration in the AVL automation system AVL PUMA Open 2™ or in the controller AVL EMCON Stand-Alone Advanced is automated while the same real-time application can be used on both systems without model adaptions.

APPLICATION

Customers can develop and execute their own real-time applications on different testbed types. Common applications are:

- Simulation of transmission models, vehicle models, engine models, testbed simulation and driver models or extended AVL standard simulation models
- Formulas: e.g. map-based feed-forward path of controllers
- Controllers: e.g. combustion controllers, media controller
- Filters: e.g. filters of higher magnitude
- On-line analysis of measured values

BENEFITS AT A GLANCE

- Seamless integration of customer-specific Simulink® models
- Fast changes to the real-time applications at run-time
- Online parameterization of models with Model Parameter Editor
- Update/calculation frequency of models up to 1 kHz
- Automated model integration in AVL PUMA Open 2™ and AVL EMCON Stand-Alone Advanced
- Central administration and distribution of real-time applications in a test field
- Rapid prototyping by model analysis at run-time with AVL ARTE.Lab 4™ Explorer

THE QUICK ENTRY TO SIMULATION

AVL ISAC 6™

MARKET REQUIREMENTS

The need for a standardized look and feel

Different systems and software products currently require a significant training period. Therefore, a lot of unused time is lost before being able to reach a smooth operation mode.

Quick entry to simulation

Simulation for non-existing hardware needs to be available but not visible. Furthermore, it is required to ensure an immediate use of the simulation on the testbed.

Robust operation on the testbed

Simulation is integrated increasingly into day-to-day tasks. This increases the demand for tools that are easy to handle and able to guarantee a robust and stable simulation.

AVL APPROACH

With AVL ISAC 6™, real-time simulation is just one click away. It allows simulation of vehicle, transmission, driver and road load.

Unified user experience

With the unified user experience of automation, control and simulation, operation of the software becomes easier. Training effort decreases, which allows an immediate productive use of the tools.

Embedded simulation

The AVL ISAC 6™ simulation is a well-integrated part of the automation system AVL PUMA Open 2™. Starting and operating the simulation needs no additional action nor effort.

BENEFITS AT A GLANCE

- Open for customer simulation models connected internally or externally
- Reproducible drive cycles
- Highly accurate and dynamic AVL ISAC 6™ driver
- Realistic gear shifting simulation for shift behavior analysis

AVL ISAC 6™ – REAL-TIME SIMULATION TRANSMISSION MODELS

The AVL models for automatic transmission, CVT (continuously variable transmission) and DCT (double clutch transmission), allow the realistic and reproducible simulation of the expected load on the combustion engine in the vehicle. Standard AVL simulation models for the driver, the vehicle and the drive train are also used for this purpose.

INTEGRATION OF OPERATING MODES

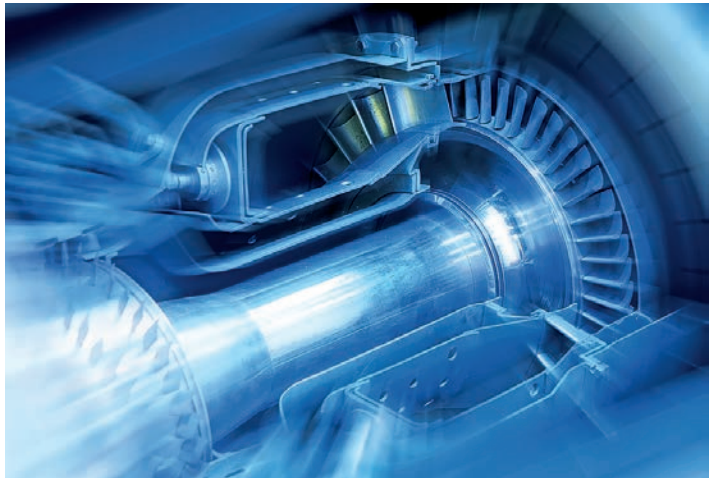
To obtain realistic measurement results of legal emission test cycles, e.g. FTP75, the AVL ISAC 6™ simulation integrates all important operating modes of the engine in the vehicle. This includes the vehicle speed control via accelerator pedal and vehicle brake as well as the simulation of realistic starting from rest and coast down.

USER-FRIENDLY PARAMETER HANDLING

All model parameters are standard transmission parameters and can be obtained from the manufacturer. Thanks to a Model Parameter Editor, they are included in a complete package. This user-friendly graphical interface makes it easy to change and store the model parameters. Additionally, the parameters can still be changed online while the test is running.

BENEFITS AT A GLANCE

- Cost saving by transferring tests from the road to the dynamic engine testbed
- No external hardware required to enable online simulation
- Reproducible results
- Models can be fully parameterized
- Integration of customer components by using AVL ARTE.Lab 4™



EFFICIENT DRIVING PLEASURE

AVL VSM 4™

Due to the constant reduction of CO_2 limits, it is necessary to find the right balance between affordable CO_2-reduction measures and a positive driving experience. Additionally, in order to save time and cost, crucial tasks have to be shifted to an earlier stage in the development process. One important aspect, in this context, is the end customer satisfaction that can be achieved by class-leading and brand-related driveability.

Therefore, the OEM's objectives are:

- Initial definition of vehicle attributes: driveability, handling, ride comfort, performance, lap time
- Early target definition & chassis development
- Early prediction and optimization of the technology required
- Forecasts of the behavior of engine/powertrain and vehicle with specific components and the effects of single component changes
- Early identification of design and calibration issues to avoid design changes
- Fast and easy calibration and validation without vehicle prototypes

AVL VSM 4™ is a comprehensive vehicle dynamics simulation package that precisely predicts vehicle behavior and enables improvement of various vehicle attributes, from the initial concept to the testing phase.

APPLICATIONS

- Driveability calibration and development in office, HiL and engine/powertrain testbeds
- Performance simulation
- Lap time optimization
- Balancing vehicle CO_2 and driving pleasure
- Handling and vehicle stability
- Steering development and testing
- Optimization of primary ride comfort on virtual shaker rig
- Active chassis and suspension development

BENEFITS AT A GLANCE

- Enhancement of vehicle driving pleasure
- Maintaining vehicle brand driving characteristics while fulfilling CO_2 legislation limits
- Reduction of development time thanks to targeted frontloading
- Significant reduction of development costs
- Surpassing competition in driving performance
- Increase of product quality

DRIVE YOUR BRAND-DNA

AVL-DRIVE 4™

Increasingly stringent emission legislation on a global level as well as cost pressure have strong effects on vehicle design and characteristics. The choice of CO_2 and efficiency measures from the powertrain to the vehicle is all about balancing cost and positive driving attributes such as driveability, handling and ride comfort, thus creating the vehicle's "DNA".

These driving attributes describe the qualitative assessment of the vehicle's response to the driver's input and are important factors of brand identification. An outstanding level of these attributes greatly enhances the overall driving experience while an acceptable level is an essential prerequisite for driving pleasure and purchase decision.

AVL supports customers to:

- Provide a high driveability quality level for vehicles with all powertrain configurations
- Handle the trade-off between emissions, fuel economy, high performance and driveability
- Guarantee an agreed vehicle character (branding)
- Manage increased vehicle complexity
- Increase efficiency (target-driven development)
- Reduce time-to-market
- Reduce development costs

APPLICATION

AVL-DRIVE 4™ allows vehicle and powertrain development engineers to objectively assess, analyze and optimize subjectively perceived powertrain and vehicle attributes such as driveability and performance, ride comfort and handling, perceived safety and driving comfort of ADAS systems.

AVL PRODUCTS FOR OBJECTIVE DRIVING ATTRIBUTES ASSESSMENT

- AVL-DRIVE 4™ – Driveability
- AVL-DRIVE 4™ – Handling
- AVL-DRIVE 4™ – Ride Comfort
- AVL-DRIVE 4™ – ADAS

BENEFITS AT A GLANCE

- Objective real-time assessment provides instant feedback on driving attributes' quality issues
- Automated driving attributes assessment, data management and reporting support efficient and target-driven development
- Common language between development areas and within the supply chain
- Reproducible assessment of driving attributes based on measured physical values
- AVL-DRIVE 4™ is designed for all phases of the development process, from pure math to lab or on-road vehicle testing